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(54) Improvements in and Relating to the Fixing of a Submerged Pipe to the Sea Bed

(57) A submerged pipe 1 is fixed to the sea bed 2 by means of ground anchors or piles 3 arranged in pairs on opposite sides of the pipe 1 and connected together by a collar 5 bearing on the pipe. The piles are introduced into pre-drilled holes and anchored initially by expansion, by injection of fluid under pressure, of an expansible device 4 associated with the pipe, and which may, as shown in Figure 1, be formed by part of the pile e.g. a wall part of thinner wall-thickness or may be a separate component associated therewith (8, Figures 2 to 7 not shown). The separate component (8) may be associated with articulated arms (17, 20 Figures 3, 4, 5) or an external tubular element (23, Figures 6, 7) having longitudinal grooves to facilitate deformation thereof. Following inflation, cement mortar may be injected e.g. through orifices 15, 16 about the pipes 3.

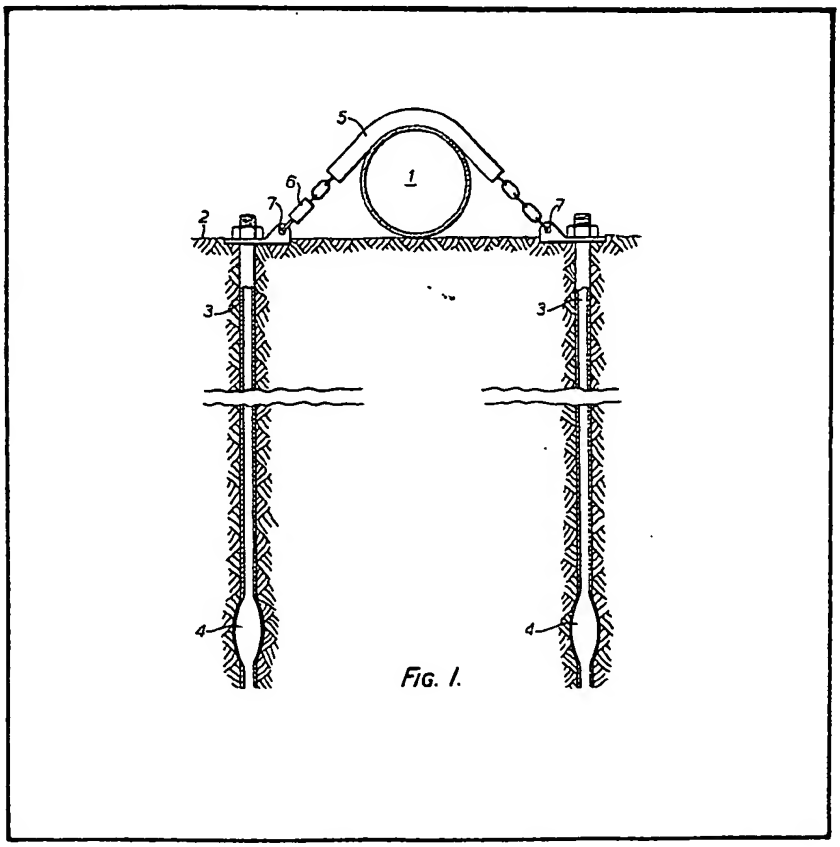

FIG. 1.

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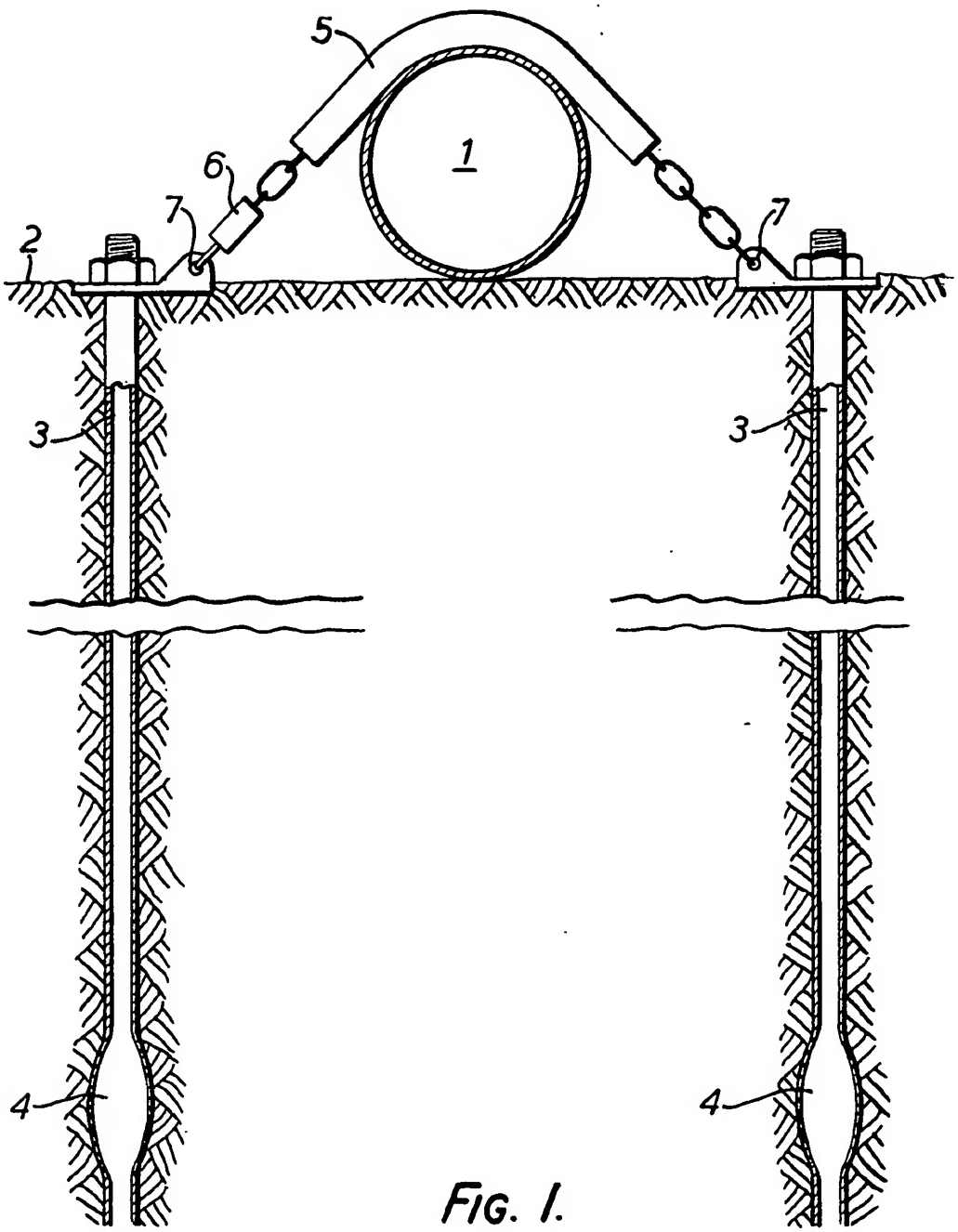

FIG. 1.

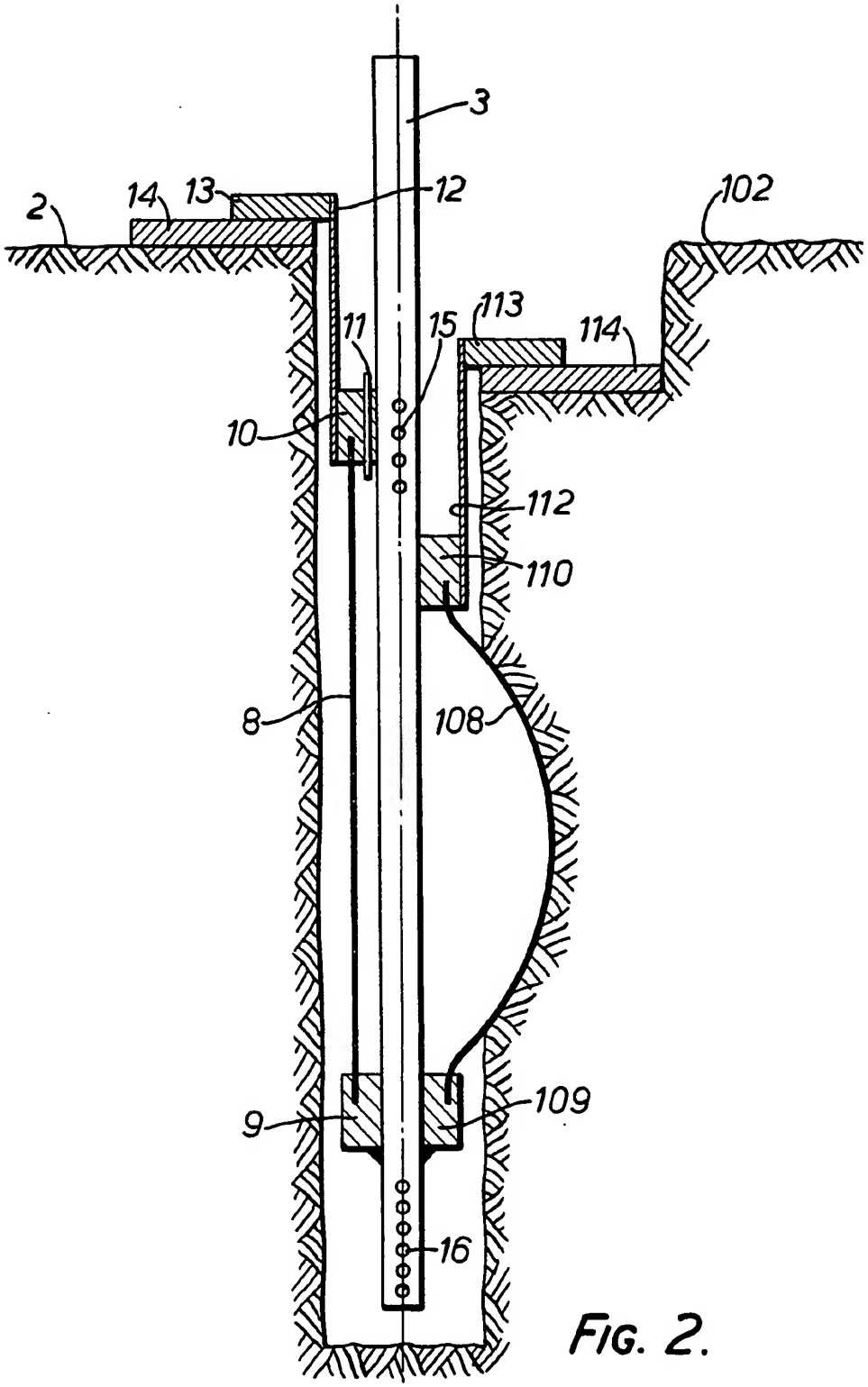

FIG. 2.

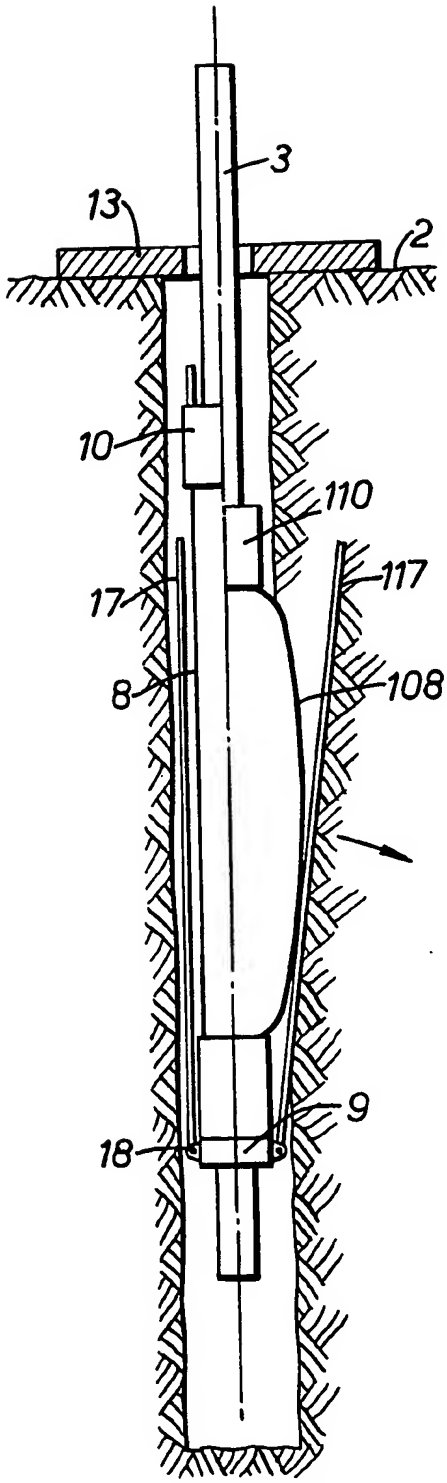
3
13
2
10
110
117
17
8
108
9
18

FIG. 3.

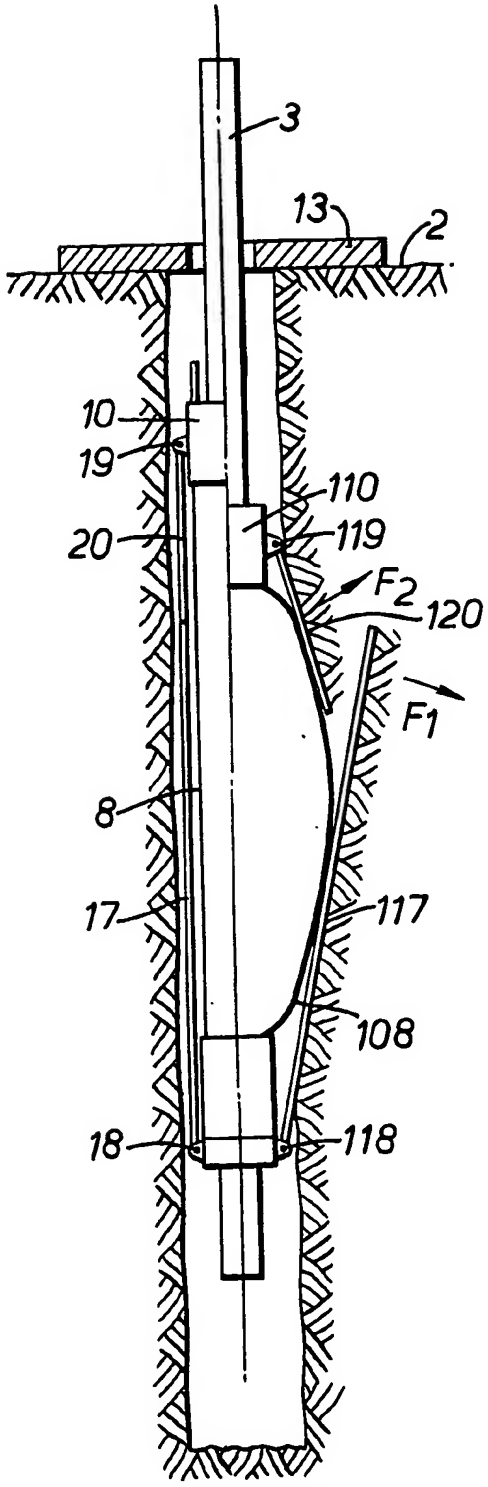
3
13
2
10
19
110
20
119
F2
120
F1
8
17
117
108
18
118

FIG. 4.

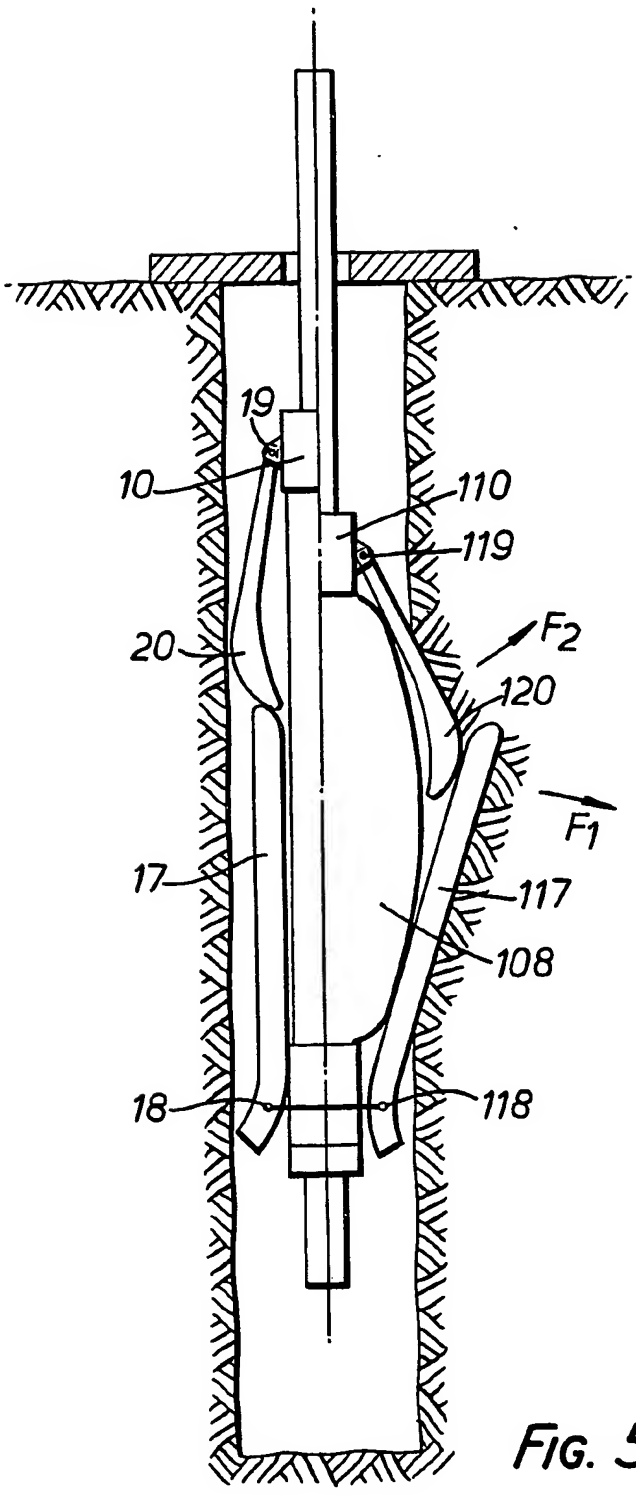

FIG. 5.

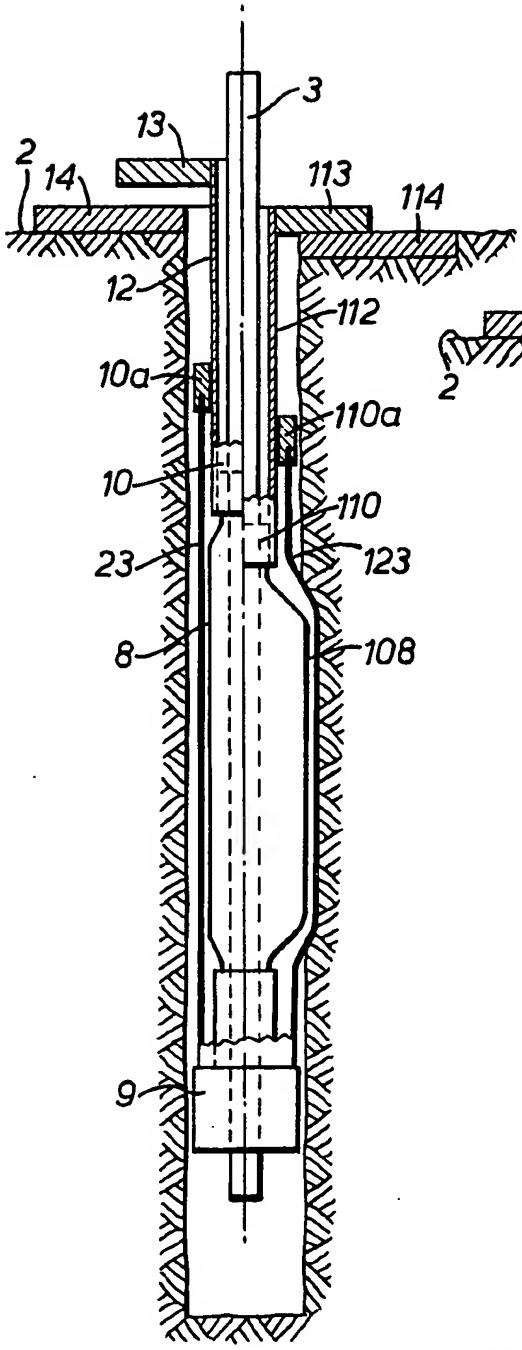
3
13
2
14
113
114
12
112
10a
110a
10
110
23
123
8
108
9

FIG. 6.

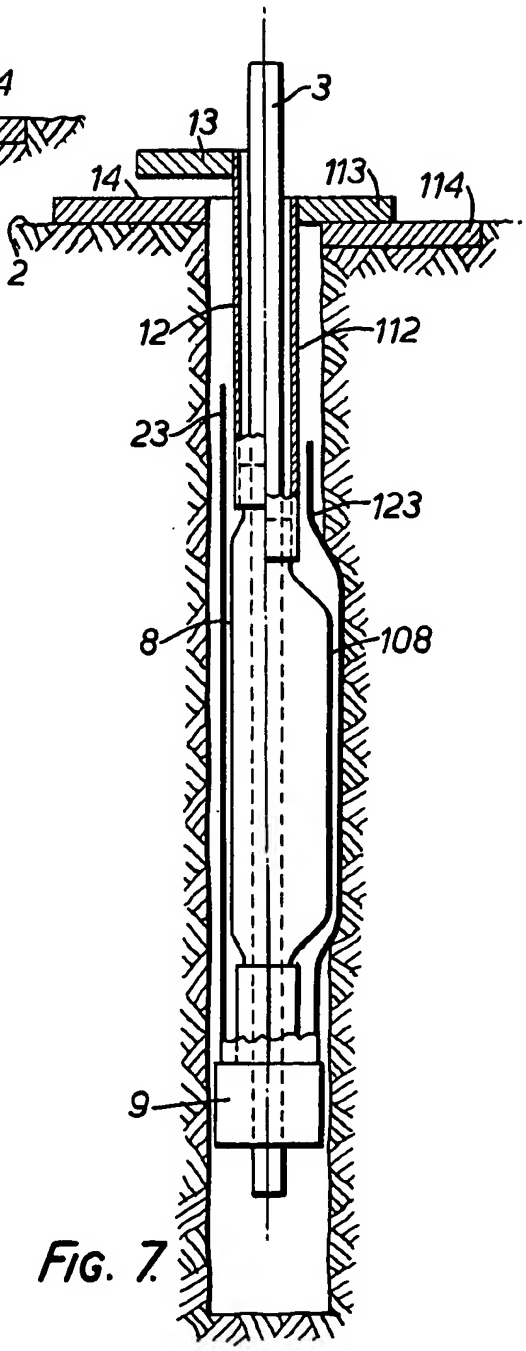
3
13
14
113
114
2
12
112
23
123
8
108
9

FIG. 7.

SPECIFICATION

Improvements In and Relating to the Fixing of a Submerged Pipe to the Sea Bed

The present invention relates to the fixing of a submerged pipe resting on a sea bed.

It is customary to lay pipes on the sea bed, and complete the laying, particularly where it is desired to take precautions against the effects of breaking waves or against marine currents which may reach speeds of five to six knots, by arranging on the pipe or pipes, from place to place, heavy riders sometimes weighing over a ton; it is also possible to enrobe the pipe or pipes with a layer of concrete, or to protect them by burying them, i.e. by placing them at the bottom of a trench then completely covering them.

On the other hand, it has been proposed to fix down already laid pipes by means of straps or collars fixed to the ends of piles driven into the sea bed by percussion. Attempts have also been made to use, instead of driven piles, piles cemented into previously drilled holes.

Such methods, which are generally time consuming and expensive, also provide little certainty, particularly in the case of storms, or else when the pipes are exposed to a breaking sea or again when they have to undergo the effects of fairly strong marine currents, which may have the effect of dislodging the pile and therefore prejudicing the entire fixing.

In the case of piles cemented into previously drilled holes, on the other hand, it is to be feared that the piles may shift from their working position before the cement has set.

Apart from their lack of reliability, methods of this type are also open to criticism for the disproportionate time involved in their performance. In fact, generally speaking, the work is done in two stages. In the first stage, the holes are drilled and then each pile is arranged in its hole as work proceeds. In the second stage, work proceeds once more along the entire length of the pipeline to cement each pile into its working position.

According to one aspect of the present invention there is provided a method of fixing a submerged pipe resting on a sea bed relative to the sea bed, comprising fixing said pipe by means of piles which are anchored in said bed, and attaching said pipe thereto by shackle means, wherein each said pile is positioned in a previously drilled hole and is anchored therein by injection of a fluid under pressure.

Preferably the various elementary operations relating to each pile are executed one after the other, the corresponding apparatus being kept in place until they are completed. Means of immobilising the relevant pile in its desired position in the centre of its hole are provided before and during the pouring of the cement mortar and until the latter is completely set.

The means to immobilise the pile in its hole comprise a device integral, or made integral, with the pile and laterally expansible, for example, by inflation with compressed air, said device presenting, before inflation, sufficiently small transverse dimensions not to interfere with the penetration of the pile into its hole.

When once inflated, said device bears strongly against the walls of the hole, so that the pile can be locked in the correct position throughout the time required for the pouring and complete setting of cement mortar, which pouring is preferably performed immediately after inflation.

The expansible device may have the form of an elongate bag, coaxial with the pile and surrounding the latter completely over a certain height. The device may be fixed to the pile at the lower part of the latter, in a firm and fluid-tight manner.

The upper part of the expansible device may be fixed fluid-tightly but axially slidably to the pile, of which the bearing region is then correspondingly machined, unless it is preferred to cover the pile with an appropriate sheath.

The expansible device may be extended upwards by a tubular sleeve, which is coaxial and external to the pile. The tubular sleeve may be connected at its upper end to a shackle, forming a sole-piece, of the anchorage system, the sole-piece resting flat upon the sea bed or, where this is considered necessary, through the intermediary of a pressure distributor plate. Upon the inflation of the expansible device, because of its transverse expansion it shortens in the longitudinal direction, and, since its lower part is fixed rigidly to the pile, its upper part, and consequently the tubular sleeve, are urged vigorously downwards, which has the effect of creating a powerful pre-stress in said sleeve, at the same time as a high compression of the surrounding ground under said sole-piece.

The pile is thus locked, both laterally and vertically, and in fact in its final working position, the expansible device having substantially a shape of revolution.

The pile may be tubular and may comprise, throughout its length, with the exception of that part inside the expansible element, orifices suitably distributed to permit the cement mortar, injected from the surface through the interior of the tube, to spread into the hole, both above and below the expansible element, after inflation of the latter; the expansible element is also provided with inflation means, such as a supply pipeline equipped with correspondingly arranged connections and valves.

Advantageously after the injection of the cement mortar as described above, mortar is also injected inside the expansible device, driving out the inflating fluid through an appropriate bleed means.

At the same time as the pouring of the mortar, straps or collars may be fixed to or over the pipe and to the heads of the piles, which results in a fresh saving of time.

According to another aspect of the invention there is provided a device for use in carrying out the above-described method comprising a tubular

pipe and an expansible device constituted by a part of the wall of said pile of reduced strength, said part being located towards the lower end of the pile. The device may be driven in, for example by percussion, whereafter the injection of the cement mortar under pressure is effected through the interior of the pile, the latter being assumed to have reached the desired depth. Under the pressure of the mortar the part of the pile wall of lower strength dilates, the pile thus becoming embedded in the walls of the hole and effecting the desired anchorage.

According to another aspect of the present invention there is provided a device for use in carrying out the above described method comprising a pile and an expansible device of elongate shape and coaxial with and external to said pile, said device being axially and fluid-tightly fixed to the lower part of said pile and being fluid-tightly and slidably fixed to an upper part of said pile.

The expansible device may be associated with an assembly of articulated arms, in the form of umbrella ribs, each arm being pivotable about its lower end on the lower fixing means of the device on the pile. The effect of lateral inflation of said expansible device is to deploy said articulated arms so that they become embedded in the walls of the hole, thus locking the pile in its axial position.

Alternatively, the expansible device may be associated with two assemblies of articulated arms, one assembly being articulated on the lower fixing means of the expansible device on the pile, and the other being articulated on the upper fixation means of the expansible device.

Each of the articulated arms may be formed, at its free end, as a sliding wedge which digs into the walls of the hole during inflation of the expansible device.

The expansible device may be associated with an external and coaxial tube, which is deformable, the tube comprising a part of lower strength obtained, for example, by making suitably arranged notches in it. On inflation of the expansible device, the tube dilates at its part of lower strength and arches or digs into the walls of the hole.

With regard to the drilling tool, which is normally fixed to the lower end of the pile, it may either be left at the bottom of the hole after the injection of the mortar, or may be recovered.

Embodiments according to the invention will now be described, by way of example only, with reference to the accompanying drawings.

In the drawings:

Figure 1 is a schematic vertical section of an embodiment of a device for use in carrying out an embodiment of the method according to the invention;

Figure 2 is a schematic vertical section of another embodiment of a device for use in carrying out the method according to the invention; and

Figures 3 to 7 show modifications of the device of Figure 2.

In Figure 1 there is shown a submerged pipe 1 laid on the sea bed 2 and which is to be firmly anchored to the bed. Two piles 3 are driven into the sea bed, one on each side of the pipe. The piles 3 are tubular and each comprises, near its lower end, a part 4 of lower strength constituted, for example, by a wall of reduced thickness. Upon the injection, through the head of the pile, of a cement mortar under pressure inside the pile, the part 4 of lower strength dilates and bears strongly against the lateral wall of the hole, even digging partly into said walls, where the ground permits this, so as to constitute a highly effective anchorage of the pile in its hole. A collar 5, as shown a chain protected by an appropriate sheath, urges the pipe 1 firmly against the sea bed 2, the collar 5 being fixed by its two ends to two shackles 7 made integral with the heads of the two piles 3. A turnbuckle 6 is interposed between one of the ends of the chain and the corresponding shackle in order to permit the regulation of the tension of the collar to the desired value.

With the aim of simplification, Figures 2 to 7 inclusive have been divided into two parts: the left-hand part of each of these figures shows, as far as the central axis thereof, a pile before inflation of an expansible device, whereas the right-hand part of the figure shows the same pile after inflation of the expansible device.

Figure 2 shows a tubular pile 3 which is provided with an expansible device 8. The device 8 is shown in its rest position in the left-hand half of the figure, whereas it is shown inflated at 108 in the right-hand half. The lower end of the expansible device 8 is fixed, firmly and fluid-tightly, by a collar 9 to the lower part of the pile 3, and the upper end is fixed by a fixing collar 10, equally fluid-tightly but slidably, to the pile, the collar 10 maintaining the upper part of the expansible device 8 on the centre line of the pile. A pressurised fluid supply pipeline 11 is provided connected to collar 10 for expansion of the expansible device 8. A complementary tubular sleeve 12, fixed to the collar 10, extends to the level of the sea bed 2, where it is assembled to the shackle 13 of the anchorage system which is supported on the sea bed by means of the sole-piece 14.

The sliding collar 10 is provided with suitable fluid-tight joints of known type, such as wedge joints, toric joints, lip joints, in order to permit the pressure inside the expansible device 8 to be maintained. For reasons of convenience, these joints have not been illustrated.

The operation of the expansible device of the pile which has just been described is as follows;

By the effect of the internal pressure within the expansible device, the expansible device 8 bears vigorously against the lateral wall of the hole and even digs partly into the latter, when the ground so permits. The shape which the device 8 then assumes is shown at 108. An important consequence of the expansion of the device is

that, by virture of its lateral inflation, the device 8 undergoes a shortening in the direction of its length, so that the collar 10 and the tubular sleeve 12 are thus strongly urged downwardly entraining the shackle 13 and the sole-piece 14, as shown in the right-hand part of Figure 2. This consequently involves a very powerful compression of the ground beneath the sole-piece 14. The sea bed 2 and the components 8, 10, 12, 13 and 14 are shown in the right-hand part of the figure, where they are respectively designated by the numbers 102, 108, 110, 112, 113 and 114.

The pile 3 is provided with a series of orifices 15, 16 for the injection of cement mortar under pressure immediately after the inflation of the device 8. In the case where it has been decided to fill the interior of the device 8 with cement, this operation is effected through the orifice 11. A bleed orifice, not shown, would then be provided on the device 8.

In the embodiment of Figure 3, the expansible device 8 is associated with a system of articulated arms 17 arranged in the form of umbrella ribs around the pile, and articulated at 18 to the lower collar 9 fixing the device 8 to the pile 3.

In the left-hand part of the figure, one of these arms 17 is shown in the rest position, and, in the right-hand part of the same figure, the arm is shown at 117 in the operative position, partly embedded in the lateral wall of the hole. This results in an extremely firm anchorage of the pile in its hole, by virtue of the embedding of the arms 17 in the ground.

As shown, the embodiment of Figure 3 does not include a tubular sleeve 12 extending from the collar 10 to the shackle 13. Such a sleeve can if required be attached thereto, in which case the right-hand part of the Figure 3 would present substantially the appearance of that of Figure 2 with, more particularly, a strong ground compression effect beneath the shackle 13, with which a sole-piece 14 could be associated.

Figure 4 illustrates a modified embodiment deriving from the embodiment of Figure 3, and in which upper arms 20 have been added to the lower arms 17. Each of these upper arms is articulated at 19 to the upper collar 10, in such a way that when the device 8 assumes its working position 108, both systems of articulated arms 17 and 20 become embedded in the walls of the hole, by pivoting in the directions of the respective arrows F1 and F2, the articulations 18 and 19 then occupy the respective positions 118 (unchanged) and 119 shown on the right-hand side of the figure.

As in the case of Figure 3, a tubular sleeve 12 may be associated with the device of Figure 4 with the same effects as previously.

Figure 5 shows a modification of the previous embodiment, in which the arms 17 and 20 are shaped at wedges at their free ends, i.e. the ends opposite those articulated on the collars. As in the case of Figure 3, a tubular sleeve 12 may be associated with the device of Figure 5, with the same effects as previously.

Figure 6 shows a further embodiment, permitting the mechanical joints described hereinbefore to be avoided and in which the expansible device 8 is associated with an external and coaxial complementary tubular element 23 provided with longitudinal grooves, the aim of which is to facilitate the deformation by the action of the expansible device.

The element 23 is fixed rigidly to the lower collar 9, but can slide, by virtue of an appropriate fixing collar 10a attached to its upper part, on the sleeve 12, or directly upon the pile 3 where no sleeve 12 is provided, in cases where no ground compression effect is required.

Upon the inflation of the device 8, the element 23 assumes the form illustrated at 123 in the right-hand part of the figure.

As with the embodiment of Figure 2, the action of the sleeve 12 is to produce a vigorous compression of the ground, contributing to the strength of the anchorage.

Figure 7 shows a modification of the embodiment of Figure 6, wherein the upper end of the complementary tubular element 23 is left free, instead of being held in a collar 10a, as in the embodiment of Figure 6.

It will be apparent that the present invention is not intended to be limited to the embodiments which have just been described, and that modifications of detail may still be made thereto, without thereby departing from the scope of the invention.

Claims

1. A method of fixing a submerged pipe resting on a sea bed relative to the sea bed, comprising fixing said pipe by means of piles which are anchored in said bed, and attaching said pipe thereto by shackle means; wherein each said pile is positioned in a previously drilled hole and is anchored therein by injection of a fluid under pressure.

2. A method of fixing a submerged pipe resting on a sea bed relative to the sea bed, comprising fixing said pipe by means of piles which are anchored in said bed, and attaching said pipe thereto by shackle means, wherein each said pile is positioned in a previously drilled hole, and fluid under pressure is injected to cause pressurisation of the adjoining ground, and the anchorage of said pile against the walls of said hole.

3. A method according to either claim 1 or claim 2, wherein consolidation of the anchorage of each said pile in said hole is effected by the injection of a cement mortar.

4. A device for use in carrying out a method according to any one of claims 1 to 3, comprising a pile and an expansible device of elongate shape and coaxial with and external to said pile, said device being axially and fluid-tightly fixed to the lower part of said pile and being fluid-tightly and slidably fixed to an upper part of said pile.

5. A device according to claim 4, wherein said expansible element is extended upwards by a sleeve coaxial with said pile and of larger

diameter, said sleeve being assembled to said shackle means.

6. A device for use in carrying out a method according to either claim 1 or claim 2, comprising a tubular pipe and an expansible device constituted by a part of the wall of said pile of reduced strength, said part being located towards the lower end of the pile.

7. A device according to either claim 4 or claim 6, wherein said pile is provided, above and below said inflatable device, with orifices for the injection of a cement mortar into the hole.

8. A device according to claim 4, comprising an assembly of articulated arms, arranged like umbrella ribs around said pile and pivotal in the region of the fixing of the inflatable element to the lower part of said pile.

9. A device according to claim 4, comprising two assemblies of articulated arms each arranged like umbrella ribs around the pile, one assembly being pivotally mounted in the region of the fixing of the expansible device to the lower part of said pile, and the other assembly being pivotally mounted in the region of the fixing of said expansible device to the upper part of said pile.

10. A device according to claim 9, wherein each of said articulated arms terminates in a bevelled shaped end portion.

11. A device according to claim 4, including, around said expansible device, a coaxial tubular element having longitudinal grooves, the lower end of said element being axially fixed to the lower part of said pile.

12. A device according to claim 11, wherein the upper part of said tubular element is arranged to slide relative to said pile.

13. A device according to claim 5, including, around said expansible device, a coaxial tubular element having longitudinal grooves, the lower end of said element being axially fixed to the lower part of said pile, and the upper part of said tubular element being slidable along said sleeve.

14. A device according to any one of claims 4 to 13, including a pipe for supply of pressurised fluid to the interior of said expansible device.

15. A device according to claim 7, wherein said pile is provided with orifices for the injection of a cement mortar and communicating with the interior of said expansible device.

16. A device according to any one of claims 4 to 15, comprising a second pile provided with an expansible device, said piles being intended to be arranged one on each side of a pipe and being arranged to receive an adjustable means co-operating with their upper ends.

17. A method according to claim 1, substantially as herein described.

18. A device according to claim 4, substantially as herein described with reference to the accompanying drawings.

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